REMARKS

Further and favorable reconsideration is respectfully requested in view of the foregoing amendments and following remarks.

Summary of Telephone Interview

Applicants wish to kindly thank the Examiner for his time and helpful comments during a telephone conversation with Applicants' representative in April of 2009. During the interview, Applicants' representative indicated that an argument presented in the prior response may have caused confusion in understanding the invention. This issue is clarified in detail below. The Examiner indicated that arguments in this regard would likely be helpful in clarifying the invention, and overcoming the prior art rejections. The Examiner recommended that Applicants file a response to the final rejection including such arguments.

Again, Applicants kindly thank the Examiner for his helpful comments.

Specification Amendments

The substitute specification (filed September 23, 2008) has been amended on page 11, line 8 to clarify that the void ratio of the fine particle may be 10% or less, in accordance with the language provided in the original specification. Accordingly, no new matter has been added to the application by this amendment.

Claim Amendments

Independent claims 1, 19 and 36 have been amended to clarify that the void ratio of each of the closely packed fine particles is 10% or less. Support for this amendment is found in the portion of the specification discussed above, i.e., page 11, lines 7-10 of the amended substitute specification. [See also page 11, lines 4 and 5 of the original specification.]

Claims 4 and 37 have been amended to delete the terms "calm" and "vigorously".

Changes of an editorial nature have been made to other claims, in order to clarify the claim language and better comply with U.S. practice.

No new matter has been added to the application by these amendments.

Rejection Under 35 U.S.C. § 112, Second Paragraph

The rejection of claims 4 and 37 as being indefinite under 35 U.S.C. § 112, second paragraph has been rendered moot in view of the above-discussed amendments.

Consideration After Final Rejection

Although this Amendment is presented after final rejection, the Examiner is respectfully requested to enter the amendments and consider the remarks, as they place the application in condition for allowance.

Patentability Arguments

The patentability of the present invention over the disclosures of the references relied upon by the Examiner in rejecting the claims will be apparent upon consideration of the following remarks.

Rejections Under 35 U.S.C. § 102(b) and 103(a)

The rejection of claims 1-4, 8-11, 13, 15-26, 28, 32-41 and 43-47 under 35 U.S.C. § 102(b) as being anticipated by Resasco et al. (U.S. Patent No. 6,413,487) in view of Baker et al. (U.S. Patent No. 5,618,875) and Ergun et al. ("Fluid Flow …") is respectfully traversed.

Additionally, the rejection of claims 15-18 and 44-47 under 35 U.S.C. § 103(a) as being unpatentable over Resasco et al., Baker et al. and Ergun as applied to claim 1 above, and further in view of Margrave et al. (U.S. Patent No. 6,645,455) is respectfully traversed.

Additionally, the rejection of claims 12 and 13 under 35 U.S.C. § 103(a) as being unpatentable over Resasco et al., Baker et al. and Ergun as applied to claims 1 and 36 above, and further in view of Smalley et al. (U.S. Patent No. 6,761,870) is respectfully traversed.

Lastly, the rejection of claim 27 under 35 U.S.C. § 103(a) as being unpatentable over Resasco et al., Baker et al. and Ergun as applied to claim 19 above, and further in view of Yamada et al. (U.S. Patent No. 5,102,647) is respectfully traversed.

<u>*The Position of the Examiner*</u>

The Examiner takes the position that Resasco et al. teach a method of producing carbon nanotubes, wherein fine particles (i.e., catalysts) are employed, and the nanotubes grow on the catalysts. The Examiner states that, to the extent Resasco et al. *may* not recite the void ratios claimed, this does not impart patentability. The Examiner asserts that Resasco et al. make mention of a fluidized bed reactor, and recite variables which affect the nanotube/nanofiber yield. The Examiner asserts that void fraction (i.e., the "empty space" in the catalyst bed) is closely intertwined with pressure, space velocity and reaction time.

The Examiner relies upon Baker et al. and Ergun et al. to teach a relationship between catalyst particle size and diameter of the filament, and a relationship between void volume and flow rate, respectively.

Regarding the obviousness rejection, the Examiner relies on Margrave et al., Smalley et al., and Yamada et al. to teach particular compounds, sulfur, and a rotary drum/kiln, respectively.

<u>*Applicants' Arguments*</u>

As mentioned above, there appears to be a misunderstanding regarding the recited limitation, "void ratio". In accordance with the Examiner's recommendation, Applicants discuss the arguments presented in the previous response, in order to clarify the apparent misunderstanding.

In short, the "void ratio" recited in Applicants' claims refers to the void ratio of <u>each</u> particle, not to the void ratio <u>between</u> particles.

On pages 2-3 of the Office Action, the Examiner refers to Applicants' arguments that the present invention is directed to a void ratio between the fine particles where carbon nanofibers grow. The Examiner takes the position that there is no difference in the void ratio between the present invention and the cited references.

Upon review of the application file, Applicants discovered an inadvertent typographical error in the previous response. Specifically, the statement "the present invention is directed to a void ratio between the fine particles where carbon nanofibers grow" (seventh paragraph on page 12 of the response filed September 23, 2008), should have stated "the present invention is directed <u>not</u> to a void ratio between the fine particles where carbon nanofibers grow", *or* "the

present invention is directed to a void ratio between <u>the components of each fine particle</u> where carbon nanofibers grow".

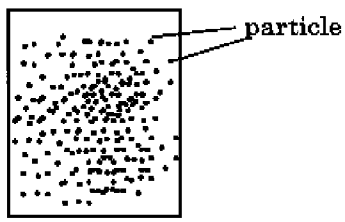
In other words, the void ratio of 10% or less recited in independent claims 1, 19 and 36 is a void ratio of <u>each of</u> the closely packed fine particles. Basis for this feature is provided on page 10, line 19 to page 11, line 14 of the original specification. This passage is recited below for the Examiner's convenience.

> In this invention, it is preferable that a void ratio <u>of</u> the fine <u>particle</u> is 30% or less in the physical separating process. This is because, when the void ratio exceeds 30%, porosity is large and wearing of particle surfaces proceeds in the physical separating process and it becomes difficult to separate and recover carbon nanofibers produced inside the particles, which is not desirable.
>
> In the present invention, in a constitution that carbon nanofibers are separated, particularly, by the physical separation process, it is preferable that the fine particles are closely packed fine particles. The closely packed fine particle means a fine particle with high strength which is not porous. More specifically, <u>the void ratio of the fine ***particle*** may be 10% or less</u>, preferably 5% or less, further preferably in a range of 3 to 5% and more preferably in a range of 1 to 3%. This is because further reduction in void ratio can prevent peeling-off in a fine particle during separation of carbon nanofibers so that carbon nanofibers which do not include impurities can be obtained. (Emphasis added.)

In other words, the void ratio of <u>a single</u> fine particle (singular form) is 10% or less. Independent claims 1, 19 and 36 have been amended to clarify this limitation. Additionally, page 11 of the specification has been amended to return to the original language referring to the void ratio of the fine particle (singular).

None of the cited references teach or suggest the void ratio of 10% or less of <u>each of</u> the closely packed fine particles, as recited in Applicants' claims. As briefly mentioned above, the Examiner states that "there is a very clear, explicit teaching of the result-effective variables in the Resasco process. Void fraction (i.e. the 'empty space' in the catalyst bed) is closely intertwined with pressure, space velocity and reaction time. This teaching is reflected in the literature. *See e.g.* (Ergun at 1182 *et seq.*) (noting the relationship between void volume and flow rate)." [Please see page 4, line 21 to page 5, line 2 of the Office Action.]

Thus, the Examiner understands that the void ratio of the references refers to a void ratio <u>between particles in a fluidized bed reactor</u>. In contrast, the void ratio recited in Applicants' claims refers to the void ratio of a <u>single closely packed fine particle</u>. The distinction is shown in the following drawings.



Resasco:
a void ratio between particles

Present Invention:
a void ratio of a particle

Additionally, attached hereto is an excerpt from <u>Fluidization Engineering</u>, by Daizo Kunii and Octave Levenspiel, which describes a general void ratio in the art. Kunii et al. disclose the same void ratio as that defined in the Resasco et al. reference. Specifically, in Fig. 1 of Kunii et al., each of the black dots indicates a particle, and the other region indicates space.

Resasco et al. describe a ratio of the space as a void ratio, and the ratio depends on a flow rate, pressure, and temperature. In contrast, the catalyst of the present invention is defined by the characteristics of particles <u>each</u> having a predetermined void ratio.

Generally, a void ratio of a flow catalyst used in a flow layer is 20% to 40%. However, Applicants' claims require a void ratio of 10% or less. A void ratio of 10% or less has an advantage in that a smaller void ratio prevents the closely packed fine particles from peeling on separation of the carbon nanofibers. Thus, Applicants' invention allows carbon nanofibers to be obtained without closely packed fine particles being an impurity.

[Applicants note that claim 1 does not recite an adhered catalyst, since the carbon nanofibers can grow even without catalyst. The catalyst component is recited in claim 11.]

For the reasons and clarifications discussed above, Resasco et al. fail to teach or suggest the limitations of Applicants' claims. Furthermore, none of the secondary references remedy the above-discussed deficiencies of the Resasco et al. reference.

Accordingly, Applicants assert that the pending claims are patentable over the cited references. Withdrawal of the above-discussed rejections is respectfully requested.

Conclusion

Therefore, in view of the foregoing amendments and remarks, it is submitted that each of the grounds of rejection set forth by the Examiner has been overcome, and that the application is in condition for allowance. Such allowance is solicited.

If, after reviewing this Amendment, the Examiner feels there are any issues remaining which must be resolved before the application can be passed to issue, the Examiner is respectfully requested to contact the undersigned by telephone in order to resolve such issues.

Respectfully submitted,

Yuichi FUJIOKA et al.

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CHAPTER 1

Introduction

Fluidization is the operation by which solid particles are transformed into a fluidlike state through suspension in a gas or liquid. This method of contacting has some unusual characteristics, and fluidization engineering puts them to good use.

The Phenomenon of Fluidization

If a fluid is passed upward through a bed of fine particles, as shown in Fig. 1(a), at a low flow rate, the fluid merely percolates through the void spaces between stationary particles. This is a *fixed bed.* With an increase in flow rate, particles move apart and a few vibrate and move in restricted regions. This is the *expanded bed.*

At a still higher velocity, a point is reached where all the particles are just suspended by the upward-flowing gas or liquid. At this point the frictional force between particle and fluid just counterbalances the weight of the particles, the vertical component of the compressive force between adjacent particles disappears, and the pressure drop through any section of the bed about equals the weight of fluid and particles in that section. The bed is considered to be just fluidized and is referred to as an *incipiently fluidized bed* or a bed at *minimum fluidization*; see Fig. 1(b).

In liquid-solid systems, an increase in flow rate above minimum fluidization usually results in a smooth, progressive expansion of the bed. Gross flow instabilities are damped and remain small, and heterogeneity, or large-scale voids of liquid, are not observed under normal conditions. A bed such as this is called a *particulately fluidized bed*, a *homogeneously fluidized bed*, or a *smoothly fluidized bed*; see Fig. 1(c). In gas-solid systems, such beds can be observed only under special conditions of fine light particles with dense gas at high pressure.

Generally, gas-solid systems behave quite differently. With an increase in flow rate beyond minimum fluidization, large instabilities with bubbling and

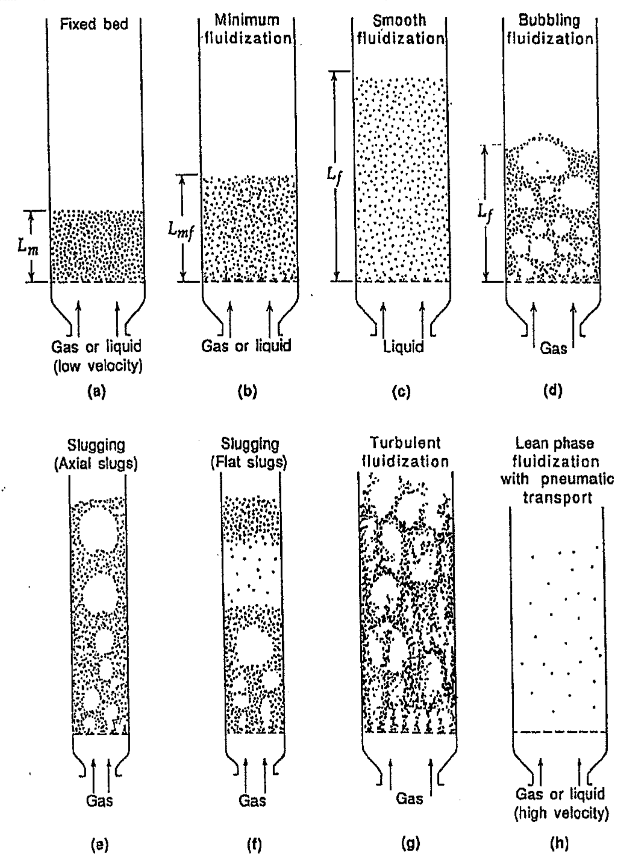

FIGURE 1
Various forms of contacting of a batch of solids by fluid.

channeling of gas are observed. At higher flow rates, agitation becomes more violent and the movement of solids becomes more vigorous. In addition, the bed does not expand much beyond its volume at minimum fluidization. Such a bed is called an *aggregative fluidized bed*, a *heterogeneous fluidized bed*, or a *bubbling fluidized bed*; see Fig. 1(d). In a few rare cases, liquid-solid systems also behave as bubbling beds. This occurs only with very dense solids fluidized by low-density liquids.

Both gas and liquid fluidized beds are considered to be *dense-phase fluidized beds* as long as there is a fairly clearly defined upper limit or surface to the bed.

In gas-solid systems, gas bubbles coalesce and grow as they rise, and in a deep enough bed of small diameter they may eventually become large enough to

spread across the vessel. In the case of fine particles, they flow smoothly down by the wall around the rising void of gas. This is called *slugging*, with *axial slugs*, as shown in Fig. 1(e). For coarse particles, the portion of the bed above the bubble is pushed upward, as by a piston. Particles rain down from the slug, which finally disintegrates. At about this time another slug forms, and this unstable oscillatory motion is repeated. This is called a *flat slug*; see Fig. 1(f). Slugging is especially serious in long, narrow fluidized beds.

When fine particles are fluidized at a sufficiently high gas flow rate, the terminal velocity of the solids is exceeded, the upper surface of the bed disappears, entrainment becomes appreciable, and, instead of bubbles, one observes a turbulent motion of solid clusters and voids of gas of various sizes and shapes. This is the *turbulent fluidized bed*, shown in Fig. 1(g). With a further increase in gas velocity, solids are carried out of the bed with the gas. In this state we have a *disperse-*, *dilute-*, or *lean-phase fluidized bed* with *pneumatic transport of solids*; see Fig. 1(h).

In both turbulent and lean-phase fluidization, large amounts of particles are entrained, precluding steady state operations. For steady state operation in these contacting modes, entrained particles have to be collected by cyclones and returned to the beds. In turbulent fluidized beds, inner cyclones can deal with the moderate rate of entrainment, as shown in Fig. 2(a), and this system is

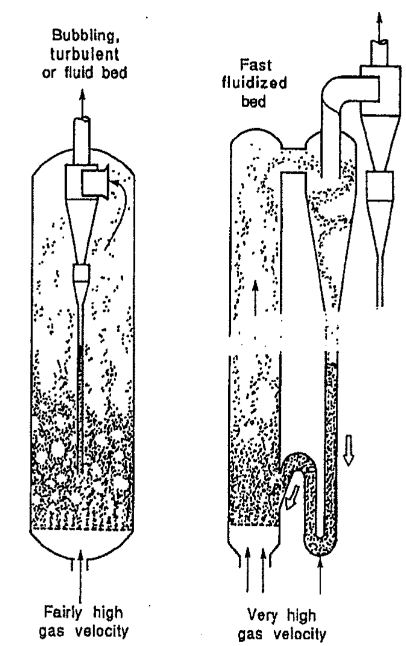

FIGURE 2
Circulating fluidized beds.